

# **MARKSCHEME**

**May 2001**

**CHEMISTRY**

**Higher Level**

**Paper 2**

# SECTION A

1. (a) (i) Tl [1]
- (ii)  $\text{Mn}^{2+}$  (accept Mn) [1]
- (iii) Any two of N, P, As, Sb, Bi [1]

- (b) Lines (may be shown on diagram) [1]  
 Convergence at high frequency / energy / short wavelength (may be shown on a diagram) [1]  
 Electron transfer between energy levels / each transition / line depends on energy differences /  $\Delta E = h\nu$  [1] [3 max]
- (c) remaining electrons in one shell /  $\text{Li}^+$  has one less shell or converse [1]  
 effective nuclear charge ( $\text{Li}^+$ ) greater than that of the atom [1] [2 max]
- (d) Any two of the following, [1] each
- Do not form bonds
  - Full outer shells
  - No attraction for electrons
  - Stable / inert / do not react
- [2 max]

2. (a)

	Pt	Cl	N	H	
Divide by $A_r$ values					[1]
No. of moles	0.3332	0.6666	0.667	2	[1]

Empirical formula  $\text{PtCl}_2\text{N}_2\text{H}_6$  [1] [3 max]

- (b) Accept any diagram that shows two Cl atoms attached to Pt **and** two  $\text{NH}_3$  groups attached to Pt. (Allow ECF from (a)). [1]
- (c) Moles of  $\text{AgNO}_3 = 0.0162 \times 0.102 = 0.00165$  [1]  
 Moles of  $\text{NaCl} = 0.0148 \times 0.125 = 0.00185$  [1]  
 Therefore limiting reactant is  $\text{AgNO}_3$  / 0.00165 moles  $\text{AgCl}$  produced [1]  
 Mass of  $\text{AgCl}$  produced =  $0.00165 \times 143.32 = 0.236$  g (accept values in range 0.236 - 0.237 g) [1] [4 max]

*If the wrong limiting reagent is used ( $\text{NaCl}$ ), 0.265 g scores [3].  
 (N.B. Error carried forward; other routes are possible for the deduction that  $\text{AgNO}_3$  is limiting / moles  $\text{AgCl} = \text{moles } \text{AgNO}_3$ )*

3. (a) (i) Energy / enthalpy change for the formation of 1 mol of a compound [1]  
from its elements in their standard states / 101 kPa, 298K [1] [2 max]
- (ii)  $3\text{C(s)} + 4\text{H}_2\text{(g)} \rightarrow \text{C}_3\text{H}_8\text{(g)}$  [1]
- (b) (i) Reference to (particular) bonds in a range of compounds / average values [1]  
Break or make 1 mole of bonds in gaseous state  
 $= [2(\text{C—C}) + 8(\text{C—H}) + 5(\text{O}=\text{O})] - [6(\text{C}=\text{O}) + 8(\text{O—H})]$  [1]  
 $= [2(348) + 8(412) + 5(496)] - [6(743) + 8(463)]$  [1] \*  
 $= -1690$  [1] (units not required) [5 max]
- (N.B. correct extraction of **five** bond enthalpy values (even with wrong coefficients) would score [1])
- (ii) Positive [1]  
Increase in disorder / less order / more gas (on RHS) [1] [2 max]
4. (a) (i) Any two of the following, [1] each  
Some mention of a **reversible** reaction  $\rightleftharpoons$  etc.  
Indication that rate of left to right = rate right to left  
At equilibrium no net change in concentration of reactants and products  
Closed system [2 max]
- (ii)  $K_c = \frac{[\text{CH}_3\text{CO}_2\text{C}_2\text{H}_5][\text{H}_2\text{O}]}{[\text{CH}_3\text{CO}_2\text{H}][\text{C}_2\text{H}_5\text{OH}]}$  [1] [1]
- (iii)  $[\text{C}_2\text{H}_5\text{OH}] = [\text{CH}_3\text{CO}_2\text{H}] = 0.33$  [1]
- $K_c = 4.1$  (accept 4.0) [1] [2 max]
- (Allow for ECF from (ii))
- (b)  $K_w$  increases with temperature rise /  $[\text{H}^+]$  or  $[\text{OH}^-]$  rises as temperature rises [1]  
Equilibrium shifts to right (as temperature increases) [1] [3 max]  
Endothermic reaction [1]
- (c) (i) No effect [1]  
Some description of role of catalyst e.g. increases rate of forward **and** reverse reaction (equally) / increases rate of attainment of equilibrium [1] [2 max]
- (ii) No effect [1]  
Concentration of reactants the same [1] [2 max]

### SECTION B

5. (a) Volume of gas method: **or** Mass loss method:  
 Chemicals in flask / beaker [1] Chemicals in flask / beaker [1]  
 Method of collection [1] Top pan balance [1]  
 Airtight [1] Not airtight [1]
- Measurement and processing:  
 Volume / mass monitoring [1]  
 Timing [1]  
 Appropriate processing of data [1]  
 e.g. convert time to rate /  $\text{rate} = \frac{1}{\text{time}}$  / plot volume–time graph and measure slope [6 max]
- (b) Slope decreases / slope becomes less steep / rate decreases [1]  
 Acid / reactant concentration falls / surface area of magnesium / reactant decreases [1] [2 max]
- (c) (i) For line B:  
 Curve shown less steep than A [1]  
 Curve becomes horizontal at half the height of A / explain why curve goes to half height [1]  
 Acid particles more widely spaced / less frequent collisions between reactant particles [1] [3 max]
- (ii) For line C:  
 Curve shown steeper than A [1]  
 Curve becomes horizontal at same height as A [1]  
 Magnesium surface area increased / more frequent collisions between reactant particles [1] [3 max]
- (d) Order = 1 / first order [1]  
 Rate proportional to concentration / graph is straight line [1] [2 max]
- (e)  $\text{Rate} = k[\text{H}_2\text{SO}_4]$  [1]  
 e.g.  $k = \frac{0.008}{0.9} \bigg/ \frac{0.006}{0.675} \approx 8.9 \times 10^{-3}$  [1] (accept answer  $\pm 2 \times 10^{-3}$ )
- $\text{s}^{-1}$  [1]  
 The value of  $k$  would be greater at a higher temperature [1] [4 max]

(f) Diagram:

Line for products below line for reactants **[1]**

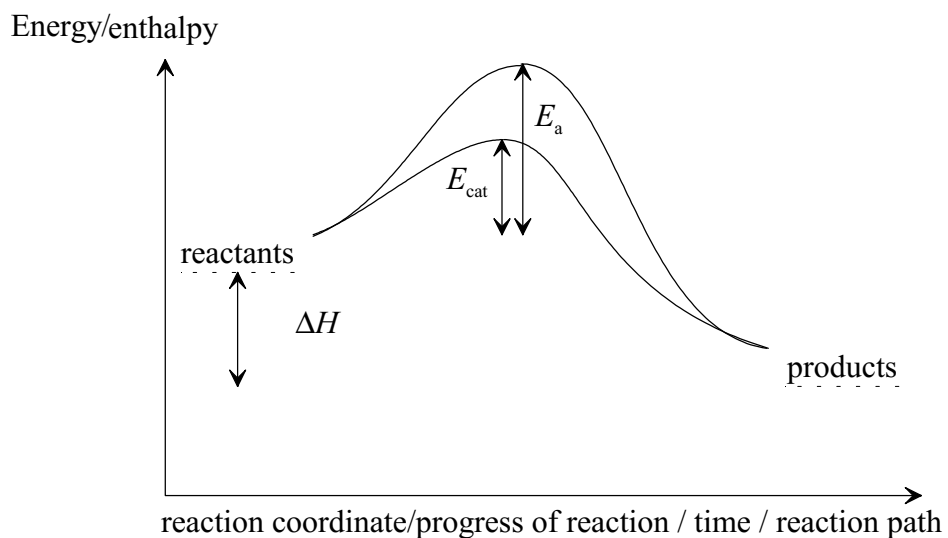
$\Delta H$  marked on vertical distance between reactants line and products line **[1]**

y axis label and x axis label or reactant and product labels **[1]**

$E_a$  marked on vertical distance between reactants line and intermediate / transition state **[1]**

$E_{cat}$  marked on vertical distance between reactants line and catalyst intermediate / transition state **[1]**

**[5 max]**



(If reaction is shown as endothermic, award **[4 max]**)

6. (a) **Brønsted–Lowry:** acid is proton ( $\text{H}^+$ ) donor and base is proton acceptor **[1]**

For example,  $\text{HNO}_3 + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+ + \text{NO}_3^-$  **[1]** (*accept other valid example*)

Identification of the acid **and** the base on the left hand side **[1]**

**Lewis:** acid is electron pair acceptor (electrophile) and base is electron pair donor (nucleophile) **[1]**

For example,  $\text{BF}_3 + \text{NH}_3 \rightarrow \text{BF}_3\text{NH}_3$  /  $\text{Cu}^{2+} + 4\text{NH}_3 \rightarrow \text{Cu}(\text{NH}_3)_4^{2+}$  **[1]**  
(*accept other valid example*)

Identification of **both** the acid and the base on the left hand side **[1]**

Bond formed is (dative) covalent / co-ordinate / indication that one species gives bonding electron pair **[1]**

**[7 max]**

- (b) Strong acid completely dissociated, weak acid weakly / partially dissociated **[1]**  
example of strong **and** weak acid (names or formulas) **[1]**

**[2 max]**

- (c) Molecule and anion equilibrium /  $\text{HIn} \rightleftharpoons \text{H}^+ + \text{In}^-$  / indicator is a weak acid or weak base **[1]**

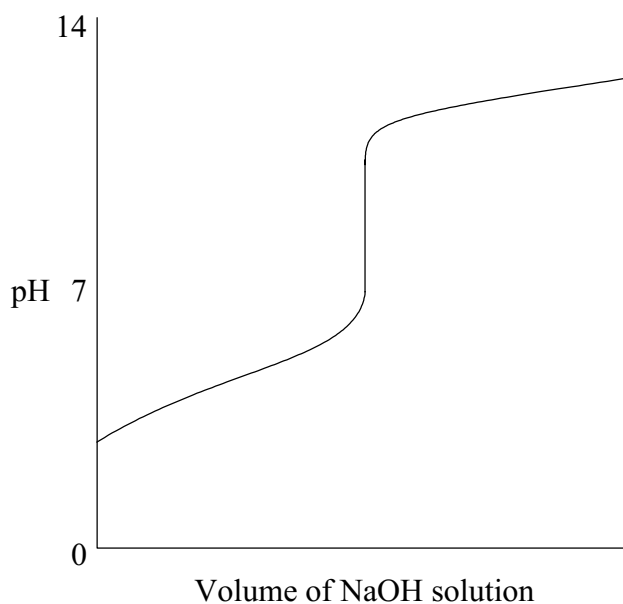
Different colours **[1]**

Addition of  $\text{H}^+$  or  $\text{OH}^-$  / acid or alkali causes shift in equilibrium **[1]**

$\text{H}^+ \rightarrow$  colour A /  $\text{OH}^-$  causes colour B **[1]**

**[4 max]**

- (d) (i)



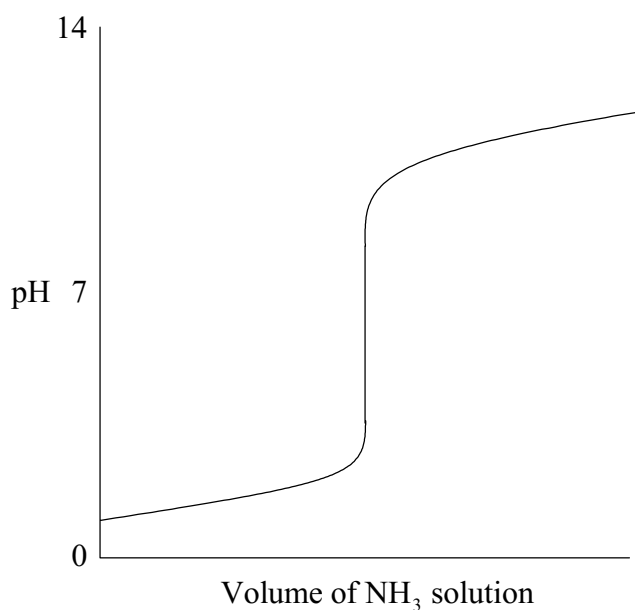
Line starts clearly above  $\text{pH} = 1$  **[1]**

More of vertical line in alkaline than acidic region **[1]**

Phenolphthalein **[1]**

**[3 max]**

(ii)

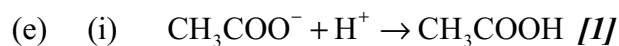


Line starts at pH = 1 / same as printed graph *[1]*

More of vertical line in acidic than alkaline region *[1]*

Methyl orange / methyl red / bromophenol blue / bromothymol blue /  
bromocresol green *[1]*

*[3 max]*



Added  $\text{H}^+$  ions react with conjugate base /  $\text{CH}_3\text{COO}^-$  *[1]*

*[2 max]*

(ii)  $[\text{H}^+] = \frac{K_a [\text{CH}_3\text{COOH}]}{[\text{CH}_3\text{COO}^-]}$  /  $\text{pH} = \text{p}K_a + \log \frac{[\text{base}]}{[\text{acid}]}$  *[1]*

Correct values of  $\text{CH}_3\text{COOH}$  and  $\text{CH}_3\text{COO}^-$  mol or  $\text{mol dm}^{-3}$  *[1]*

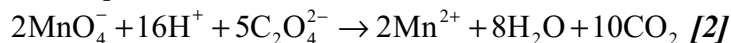
Correct value of  $[\text{H}^+] = 3.48 \times 10^{-5} (\text{mol dm}^{-3})$  *[1]*

pH = 4.4–4.5 (consequential on  $[\text{H}^+]$  value) *[1]*

*[4 max]*

7. (a) Oxidation number of Mn on left-hand side 7 **[1]**  
 Oxidation number of C on left-hand side 3 **[1]**  
 Oxidation number of Mn **and** C on right-hand side 2 and 4 respectively **[1]**

Final equation:



*(If ratio  $\text{MnO}_4^- : \text{C}_2\text{O}_4^{2-}$  is 2 : 5 but equation wrong give [1]. Do not penalise absence of state symbols)*

**[5 max]**

- (b) (i) Diagram must show:  
 Voltmeter and metals **[1]**  
 Salt bridge correctly labelled **[1]**  
 $[\text{Ni}^{2+}]$  **and**  $[\text{Cd}^{2+}]$  as 1 mol dm<sup>-3</sup> **[1]**

**[3 max]**

- (i) • H<sub>2</sub> gas  
 • At 1 atm / 101.3 kPa  
 • 298 K  
 • 1 mol dm<sup>-3</sup> H<sup>+</sup>

*(Four correct [2], 2/3 correct [1])*

Pt electrode **[1]**

**[3 max]**

- (c) (i)  $\text{Ni}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Ni}(\text{s})$  **[1]**  
 $\text{Cd}(\text{s}) - 2\text{e}^- \rightarrow \text{Cd}^{2+}(\text{aq})$  /  $\text{Cd}(\text{s}) \rightarrow \text{Cd}^{2+}(\text{aq}) + 2\text{e}^-$  **[1]**  
 Allow  $\text{Cd} + \text{Ni}^{2+} \rightarrow \text{Cd}^{2+} + \text{Ni}$  for **[2]**

Cd is oxidised **[1]**

Oxidising agent is  $\text{Ni}^{2+}$  (do not accept Ni) **[1]**

**[4 max]**

- (ii) Cd is A **[1]**  
 External electron flow from Cd to Ni **[1]**.

**[2 max]**

- (iii) Overall voltage is 0.2 volts (accept + or – 0.2 V) **[1]**  
 $\Delta G$  is negative (consequential on the sign of the potential) **[1]**

**[2 max]**

- (d) Silver at cathode / - ve **[1]**  
 Oxygen at anode / + ve **[1]**

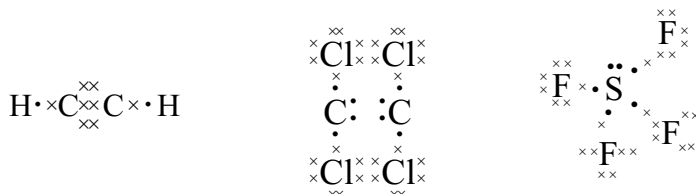
**[2 max]**

- (e) Number of coulombs =  $20 \times 5 \times 60^2$  / 360000 **[1]**  
 Number of Faradays = 3.73 **[1]**  
 Moles of OH<sup>-</sup> = 3.73 **[1]**  
 Mass of NaOH =  $3.73 \times 40 = 149.2$  g **[1]**

**[4 max]**



8. (a) Each structure (**with** non-bonding  $e^-$  pairs where relevant) [1]  
(lines are acceptable instead of pairs of dots/crosses)



Shapes:

$\text{C}_2\text{H}_2$  linear / straight [1]  
angle  $180^\circ$  [1]

$\text{C}_2\text{Cl}_4$  (trigonal) planar [1]  
angle  $120^\circ$  [1]

$\text{SF}_4$  K-shaped / based on trigonal bipyramid / see saw [1]  
angle  $90^\circ$  [1]  
angle  $120^\circ$  [1]

[10 max]

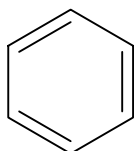
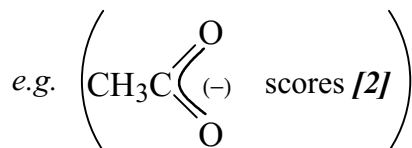
- (b)  $sp$  ( $\text{C}_2\text{H}_2$ ) [1]  
 $sp^2$  ( $\text{C}_2\text{Cl}_4$ ) [1]

[2 max]

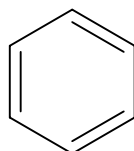
- (c) Acceptable resonance structures



(accept delocalized ethanoate ion for [2])



[1]



[1]

[4 max]

(accept delocalized benzene for [2])

- (d) (i) C to O in the ion equal **[1]**  
 Different bond length in acid **[1]**  
 $C=O < C-O$  (or converse) **[1]**  
 C to O in ethanoate ion intermediate bond length / 1.5 bonds **[1]** **[4 max]**
- (ii) Benzene is stable because of delocalization **[1]**  
 Addition destroys delocalization **[1]** **[2 max]**
- (iii) ( $pK_a$  values show) ethanoic stronger acid than ethanol **[1]**  
 (Some correct statement about difference in acidity)
- Reference to relative stability of (both) anions (*they do not have to be shown*) **[1]**
- Anion of acid more stable C = O group  $e^-$  withdrawing / delocalisation of charge (or resonance) in ethanoate ion / explain instability of ethoxide **[1]** **[3 max]**
-